APPLICATION UNDER UNITED STATES PATENT LAWS

Atty. Dkt. No. PW 0276921
(M#)

Invention: INTEGRATED HEAT SPREADER WITH MECHANICAL INTERLOCK DESIGNS

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☐ Provisional Application

☒ Regular Utility Application

☐ Continuing Application
☒ The contents of the parent are incorporated by reference

☐ PCT National Phase Application

☐ Design Application

☐ Reissue Application

☐ Plant Application

☐ Substitute Specification
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SPECIFICATION

INTEGRATED HEAT SPREADER WITH MECHANICAL INTERLOCK DESIGNS

BACKGROUND

1. Field

[0001] This invention relates generally to packaging for integrated circuits. More specifically, this invention relates to a novel integrated heat spreader.

2. Background and Related Art

[0002] Integrated circuits generate heat to varying degrees. In typical applications, such radiated heat must be dissipated to ensure that thermal effects do not impair the performance of, or even damage, integrated circuits. With increasing demands in computing speeds and memory, heat removal has become a critical focus area in packaging. Various techniques have been employed to dissipate radiated heat effectively, including the attachment of integrated heat spreaders (heatsinks) or fans to integrated circuits.

[0003] FIG. 1 (Prior Art) illustrates portions of an electronic package 100. Package 100 includes a die 110, a substrate 120, and pins 130. An integrated heat spreader 101 is adhesively attached to substrate 120 via a sealant. Heat spreader 101 absorbs heat radiated by die 110 and substrate 120.

[0004] FIG. 2 (Prior Art) illustrates a portion of another electronic package 200. Package 200 includes a die 210, a substrate 220, and pins 130. Heat spreader 201 is attached to substrate 220 via an adhesive bond 240. Heat spreader 201 is in contact with die 210 to absorb radiated heat of die 210. Heat spreader 201 includes lips 250

that extend from the heat spreader and adhere, via adhesive bond 240, to substrate 220. In package 200, one face of each lip 250 is in contact with adhesive bond 240.

[0005] The splitting or separating of a laminate into layers is known as delamination. In particular, heat spreader-to-sealant delamination in electronic packages may lead to the popping off of heat spreaders from the integrated circuits to which they are attached. For instance, heat spreader 201 may pop off of substrate 220, causing package 200 to fail. Moreover, high combined shear and tensional stress distributions are often exhibited by packages with off-center dies. Because of severe shear stress (torsional) distributions, heat spreader-to-sealant interfacial delamination may occur. Heat spreader-to-sealant adhesion may be unable to withstand the high shear stresses generated at the heat spreader-to-sealant interface.

[0006] Therefore, what is needed is an improved integrated heat spreader.

BRIEF DESCRIPTION OF THE DRAWINGS

[0007] FIG. 1 (Prior Art) illustrates portions of an electronic package.

[0008] FIG. 2 (Prior Art) illustrates portions of an electronic package.

[0009] FIGs. 3A and 3B are plan and side views, respectively, of an integrated heat spreader according to an embodiment of the present invention.

[0010] FIGs. 4A and 4B are plan and side views, respectively, of an integrated heat spreader according to an embodiment of the present invention.

[0011] FIGs. 5A and 5B are plan and side views, respectively, of an integrated heat spreader according to an embodiment of the present invention.

[0012] FIGs. 6A and 6B are plan and side views, respectively, of an integrated heat spreader according to an embodiment of the present invention.

DETAILED DESCRIPTION

[0013] An integrated heat spreader, as presented herein, is constructed and arranged to be adhesively affixed, with a sealant, to at least a portion of a component, such as a substrate. The heat spreader includes a body portion, a lip portion substantially vertically oriented and integrally formed with the body portion, and a step portion integrally formed with the lip portion. As such, adhesion of the heat spreader to the sealant is increased, and failure due to shear stresses at the heat spreader bonding surface is prevented.

[0014] FIGs. 3A and 3B are plan and side views, respectively, of an integrated heat spreader 300 according to an embodiment of the present invention. Heat spreader 300 includes a heat spreader element 301. Heat spreader element 301 may be shaped to suit a particular application. For instance, heat spreader element 301 may be rectangular or square. Lips 310 extend substantially vertically from heat spreader element 301. A step 320 extends from each lip 310 and may be regularly or irregularly shaped. In the embodiment of FIGs. 3A and 3B, steps 320 are rectangular and extend laterally from lips 310 in a substantially perpendicular manner.

[0015] Heat spreader element 301, lips 310, and steps 320 may be respectively formed of the same materials or different materials. Exemplary materials include copper, copper with a nickel or other coating, aluminum, a carbon/carbon composite, or a carbon/metal composite. Exemplary carbon/metal composites include carbon/copper and matrix fiber reinforced composites. Heat spreader 300 may be selectively plated or plated over its entire surface area. Exemplary electrolytic plating materials include gold, silver, tin, nickel, and metal composites.

[0016] A thermal interface material (TIM) may be placed between the die and the heat spreader cavity interfaces. A TIM can be a solder, a polymer/solder composite, or a polymer.

[0017] A sealant may be employed to affix heat spreader 300 to other objects, such as package components, including a substrate (not shown). In exemplary implementations, silicone- or epoxy-based sealants may be employed.

[0018] Sealant flows over each step 320 to form a mechanical link. Sealant flow 370 is identified in FIG. 3B. In various embodiments, thickness of sealant at the heat spreader surface ranges from 1.5 mm to 3 mm, and extended lips 310 are 2 mm wide.

[0019] According to embodiments of the present invention, an extension to lip 310, such as step 320, increases the surface area of each lip 310 of heat spreader 300. Thus, sealant coverage over heat spreader 300 increases, and the sealant may better grip heat spreader 300. More specifically, shear stress is distributed above and below lips 310, providing greater area in which to absorb and dissipate stresses. The strength of the sealant in the areas of mechanical linkage, coupled with the adhesive bonding energy, increases the bonding strength and may prevent failure due to shear stresses at the heat spreader-to-sealant interface.

[0020] In sum, embodiments of the present invention, which include mechanical links at the heat spreader-to-sealant interface, increase adhesion of the sealant to the heat spreader and to a package component, such as a substrate. As such, a sealant is more likely to fail at the substrate interface or cohesively within the sealant than to fail adhesively at the head spreader bonding surface.

[0021] FIGs. 4A and 4B are plan and side views, respectively, of an integrated heat spreader 400 according to an embodiment of the present invention. Heat spreader

400 includes a heat spreader element 401 and lips 410 extending therefrom. A step 420 extends from each lip 410. As shown in FIG. 4A, each step 420 includes holes 430. Holes 430 may comprise, for example, circular holes or slots. Sealant may flow through each hole 430 and over each step 420, forming a mechanical link. Sealant 470 is depicted in FIG. 4B.

[0022] FIGs. 5A and 5B are plan and side views, respectively, of an integrated heat spreader 500 according to an embodiment of the present invention. Heat spreader 500 includes heat spreader element 501. Lips 510 extend from heat spreader element 501. A step 520 extends from each lip 510. Each step 520 includes cutouts 540. In some embodiments, edges of cutouts 540 may be rounded. Sealant may flow through cutouts 540 and up over step 520 to form a mechanical link. Sealant 570 is shown in FIG. 5B.

[0023] FIGs. 6A and 6B are plan and side views, respectively, of an integrated heat spreader 600 according to an embodiment of the present invention. Heat spreader 600 includes an integrated heat spreader element 601. Lips 610 extend from heat spreader element 601. Each lip 610 includes a channel 650, which may be concave. During the process of attaching heat spreader 600 to a substrate or other component, sealant may flow into channel 650 to form a mechanical link. Deeper and sharper channels may achieve greater reductions in delamination, increasing the ability of the sealant to adhere to heat spreader 600 under higher stresses. One or more channels of the same or different dimension can be utilized.

[0024] The integrated heat spreader structures described above may be fabricated in various ways. For instance, extensions, holes, slots, cutouts, and channels may be stamped during a stamping operation associated with an integrated heat

spreader. Alternatively, structures may be formed by grinding or laser etching after a stamping operation associated with an integrated heat spreader.

[0025] The foregoing description of the preferred embodiments is provided to enable any person skilled in the art to make or use the present invention. Various modifications to these embodiments are possible, and the generic principles presented herein may be applied to other embodiments as well. As such, the present invention is not intended to be limited to the embodiments shown above but rather is to be accorded the widest scope consistent with the principles and novel features disclosed in any fashion herein. In particular, variations and combinations of embodiments presented above may be incorporated into integrated heat spreaders. For instance, cutouts may be irregularly spaced, and a step or lip may have a channel, multiple channels, or notch in a lateral face.